(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 410 074 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
25.01.2012 Bulletin 2012/04

(51) Int Cl.:
C23C 14/28 *(2006.01)* ***C23C 14/54*** *(2006.01)*

(21) Application number: **10170223.1**

(22) Date of filing: **21.07.2010**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
BA ME RS

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(54) Heat shield and filter

(57) The invention relates to a device for pulsed laser deposition, which device comprises:
- a substrate mount with a substrate mounting surface for a substrate;
- a target mount for a piece of target material arranged substantially parallel to and at a distance from the substrate mount;
- a laser device for directing a laser beam on a piece of target material mounted on the target mount, such that a plasma plume of target material is generated and deposits on the substrate; and
- a first shield arranged between the substrate mount and the target mount for shielding the target, wherein the first shield comprises at least one passage opening for passage of at least the generated plasma plume; and
- a rotating wheel having at least one passage opening extending from one side of the wheel to the opposite side, wherein, seen in the direction perpendicular to shield surface with the passage opening, the wheel overlaps with the passage opening in the shield and the path of the passage opening in the wheel overlaps with the passage opening in the shield.

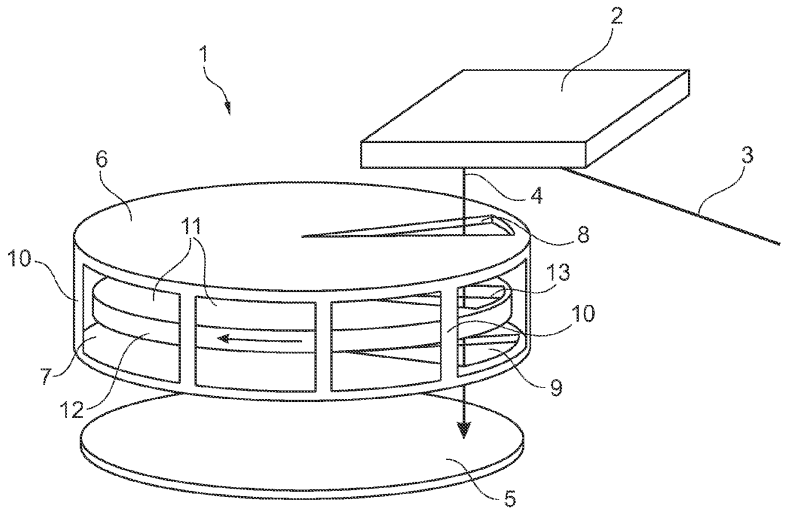

Fig. 1

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Description

[0001] The invention relates to a device for pulsed laser deposition.

[0002] Pulsed laser deposition (PLD)is a known technique for arranging a coating on an object. With this technique material of a target material is ablated by a laser, such that a plasma plume of this target material is generated. This plasma plume then is deposited on a substrate resulting in a coating of the target material on the substrate.

[0003] PLD was at first developed for coating small substrate surfaces, typically 10 millimeters by 10 millimeters. This is typically used in research environments, where small substrates are coated with all kinds of materials with high thin film quality.

[0004] Resulting from this research a need to coat larger surfaces originated. This has resulted in innovative techniques with which surfaces having a typical diameter of several inches or more can be coated.

[0005] In order to coat some substrate materials with PLD with the correct material properties, such as crystal structure and texture, it is often necessary to heat the substrate to temperatures of typically 200°C - 1000°C.

[0006] When a small substrate surface of about 10x10 millimeters is heated up to 200°C - 1000°C, the heat radiation does not influence too much the target material arranged opposite to the substrate material. However, as the size of the substrate surface is increased, the heat radiation is also increased resulting in an unacceptable influence on the target material. This could result in early evaporation of components of the target material, such that the deposited coating on the substrate is of another composition than the original composition of the target material.

[0007] Another problem with PLD is that there are side-products formed during the laser evaporation process. These side products or so-called particulates or droplets have a lower speed compared to the plasma especially near the target area. The speed difference between the plasma and the slow particulates relates to the process conditions. Speeds of the particulates vary from 1-300 m/sec while the plasma speed directly from the target is in the order of 500-20.000 m/sec. The plasma speed depends on the pressure in the chamber and the distance from the target. The side products are substantially originating from the target as a point-source while the plasma is more oriented in the target-substrate direction.

[0008] Particulates or so-called droplets during laser ablation are very common and will be co-deposited on the substrate as well , which influence the thin film quality of the PLD process. These particles generate all kinds of unwanted defects in the film. Especially if PLD is used to deposit large substrates and the beam is scanned the contribution of particles in and on the film increases.

[0009] It is an object of the invention to reduce the effects of the above mentioned particles or so-called droplets.

[0010] This object is achieved by the invention with a device comprising:

- a substrate mount with a substrate mounting surface for a substrate;
- a target mount for a piece of target material arranged substantially parallel to and at a distance from the substrate mount;
- a laser device for directing a laser beam on a piece of target material mounted on the target mount, such that a plasma plume of target material is generated and deposits on the substrate; and
- a first shield arranged between the substrate mount and the target mount for shielding the target, wherein the first shield comprises at least one passage opening for passage of at least the generated plasma plume; and
- a rotating wheel having at least one passage opening extending from one side of the wheel to the opposite side, wherein, seen in the direction perpendicular to shield surface with the passage opening, the wheel overlaps with the passage opening in the shield and the path of the passage opening in the wheel overlaps with the passage opening in the shield.

[0011] The first shield provides a shield for the major part of the substrate and the passage opening provides access for the plasma plume, which is intended for only a small part of the surface. The shield accordingly shields off some of the unwanted particles.

[0012] The first shield also protects the substrate and target from heat irradiated from the heated target material as well as heat irradiated from the heated substrate. Preferably the first shield is cooled to further protect the substrate and target from heat.

[0013] The rotating wheel provides a filter for the plasma plume. As the plasma plume has a substantial higher speed, than the undesired particles or droplets, the passage opening in the wheel can be controlled such, that the plasma plume can go from the target material through the passage opening in the first shield and through the wheel to the substrate, while the wheel can close off the passage as soon as the undesired particles or droplets arrive. These droplets will then be caught by the wheel preventing a film being formed on the substrate by the undesired particles or droplets.

[0014] In a preferred embodiment of the device according to the invention, a second shield is arranged parallel to the first shield and on the opposite side of the wheel, wherein the second shield comprises at least one passage opening, which overlaps with the at least one passage opening in the first shield.

[0015] The second shield can further reduce the heat radiation to the substrate as well as the target and can further shield off particles arriving at the substrate.

[0016] Preferably, the first shield and the second shield are connected at the circumference by a side wall. A housing is formed by both shields and the side wall, such

that the rotating wheel is protected. The wheel has a typical rotation speed of 10Hz - 1000Hz, which increases safety of the PLD device.

[0017] In another embodiment of the device according to the invention the passage opening in the heat shield closest to the target mount is smaller than the passage opening in the heat shield closest to the substrate mount. The plasma plume originates as a point source from the target, such that a small passage opening is needed in the shield closest to the target mount. The surrounding particles and droplets are then already partially blocked just by a small passage opening.

[0018] In another preferred embodiment of the device according to the invention, the wheel comprises a hub with a number of vanes evenly distributed over the circumference of the hub. The space between the vanes provide passage openings for the plasma plume to pass the rotating wheel, while the lagging cloud of undesired particles is wiped away by the following vane from the wheel.

[0019] Preferably, the vanes of the wheel have a transverse cross section with a uniform thickness, such that the displacement of air by the vanes is minimized. If the cross section of a vane in the travel direction of a plasma plume, is constant, the aerodynamic lift effect is not obtained, such that the ambient air is not being propelled, which would otherwise result in undesired airflows within the PLD device, which would disturb the depositing of the plasma on the substrate. The thickness of the vanes in longitudinal direction could vary for example due to strength and stiffness requirements.

[0020] Preferably the number of vanes is a prime number. This ensures that the particles being wiped away by the vanes is evenly distributed over the prime number of vanes. Accordingly, the stability of the rotating wheel is not affected by the additional particles being deposited on the vanes.

[0021] Yet another embodiment of the device according to the invention comprises a controller for controlling the laser beam dependent on the position of the passage opening in the wheel. The controller ensures that the laser is fired at exactly the correct moment, such that the filtering action of the wheel is optimized. The passage opening in the wheel should just close of the passageway as soon as the plasma plume has passed the wheel and the cloud of droplets is still present within the passage opening in the wheel or even in front of the wheel.

[0022] These and other features of the invention will be elucidated in conjunction with the accompanying drawings.

Figure 1 shows a schematic perspective view of a first embodiment according to the invention.

Figure 2 shows a cross sectional view of a second embodiment according to the invention.

Figure 3 shows the wheel of figure 2 in perspective view.

Figure 4 shows an enlarged cross sectional view of figure 2.

[0023] Figure 1 shows a first embodiment 1 of a device for pulsed laser deposition according to the invention. This device 1 has a target mount 2 with a target material. A laser beam 3 is directed on the surface of the target material, to generate a plasma plume 4. This plasma plume 4 is deposited on a substrate 5.

[0024] A first shield 6 and a second shield 7 are arranged between the target mount 2 and the substrate 5. The first shield 6 closest to the target mount 2 has a small passage opening 8 and the second shield 7 has a somewhat larger passage opening 9.

[0025] The first shield 6 and the second shield 7 are connected by a peripheral side wall 10, which comprises a number of openings 11. The first shield 6, second shield 7 and the peripheral side wall 10 constitute a housing for a rotating wheel 12. This rotating wheel 12 has a passage opening 13 and functions as a mechanical filter for the plasma plume 4.

[0026] Figure 2 shows a cross sectional view of a second embodiment 20. This embodiment corresponds partially with the embodiment 1 of figure 1. Similar parts are identified with the same reference signs.

[0027] The device 20 has a target mount 2 and a substrate 5. Between the target mount 2 and the substrate 5 a housing of a first shield 6 and a second shield 7 is arranged.

[0028] In the housing 6, 7, 10 a hub 21 with vanes 22 is arranged. This hub 21 with vanes 22 is shown in figure 3 in more detail.

[0029] From figure 2 it is clear, that the plasma plume 4 can move freely from the target material 2 through the passage opening 8, between the vanes 21 and through the passage opening 9 to the substrate 5. The vanes 21 have a constant thickness, such that no gas flow in the direction of the plasma plume 4 is generated by rotating the vanes 21. Although PLD is performed in near vacuum there will still be some gases present, which could disturb the plasma plume. By designing the vanes 22 such, that the vanes will not propel the gases, the plasma plume will at least substantially not be disturbed.

[0030] In figure 4, the filtering action of the rotating wheel 21, 22 is shown.

[0031] The laser beam 3 irradiates the target material 2, such that a plasma 23 is generated. This plasma 23 flows from the target material 2 through the passage opening 8, between the vanes 22 and through the passage opening 9 towards the substrate 5.

[0032] The plasma 23 is followed by a cloud 24 of undesired particles and droplets. By controlling the laser beam 3 depending on the position of the vanes 22, the cloud 24 can be wiped away by a vane 22, just after the plasma 23 passes the vanes 22. The cloud 24 is then deposited on one of the vanes 22 and the filtering action is performed.

Claims

1. Device for pulsed laser deposition, which device comprises:

   - a substrate mount with a substrate mounting surface for a substrate;
   - a target mount for a piece of target material arranged substantially parallel to and at a distance from the substrate mount;
   - a laser device for directing a laser beam on a piece of target material mounted on the target mount, such that a plasma plume of target material is generated and deposits on the substrate; and
   - a first shield arranged between the substrate mount and the target mount for shielding the target, wherein the first shield comprises at least one passage opening for passage of at least the generated plasma plume; and
   - a rotating wheel having at least one passage opening extending from one side of the wheel to the opposite side, wherein, seen in the direction perpendicular to shield surface with the passage opening, the wheel overlaps with the passage opening in the shield and the path of the passage opening in the wheel overlaps with the passage opening in the shield.

2. Device according to claim 1, comprising a second shield arranged parallel to the first shield and on the opposite side of the wheel, wherein the second shield comprises at least one passage opening, which overlaps with the at least one passage opening in the first shield.

3. Device according to claim 2, wherein the first shield and the second shield are connected at the circumference by a side wall.

4. Device according to claim 2 or 3, wherein the passage opening in the heat shield closest to the target mount is smaller than the passage opening in the heat shield closest to the substrate mount.

5. Device according to any of the preceding claims, wherein the wheel comprises a hub with a number of vanes evenly distributed over the circumference of the hub

6. Device according to claim 5, wherein the vanes of the wheel have a transverse cross section with a uniform thickness, such that the displacement of air by the vanes is minimized.

7. Device according claim 6, wherein the number of vanes is a prime number.

8. Device according to any of the preceding claims, further comprising a controller for controlling the laser beam dependent on the position of the passage opening in the wheel.

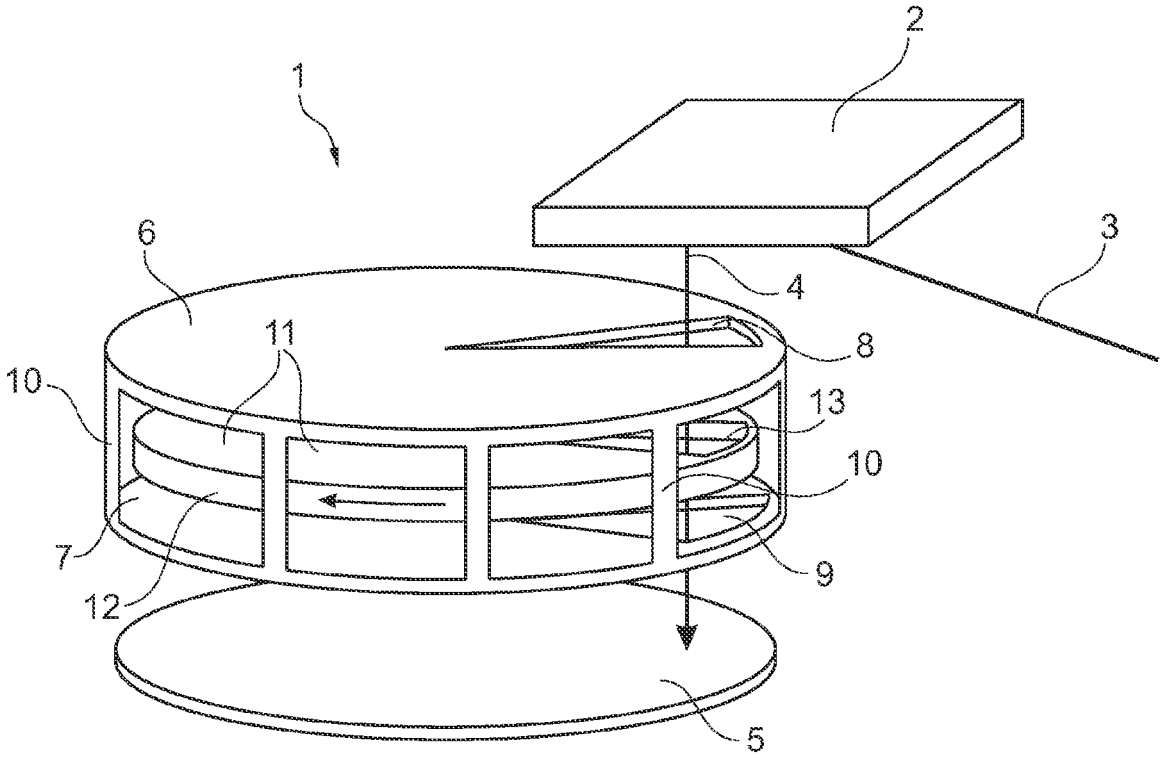

Fig. 1

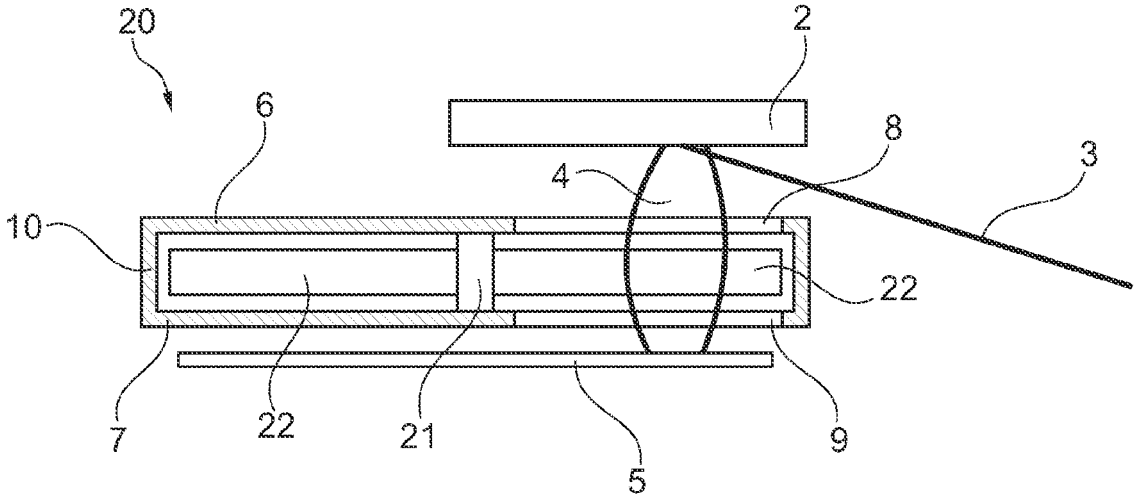

Fig. 2

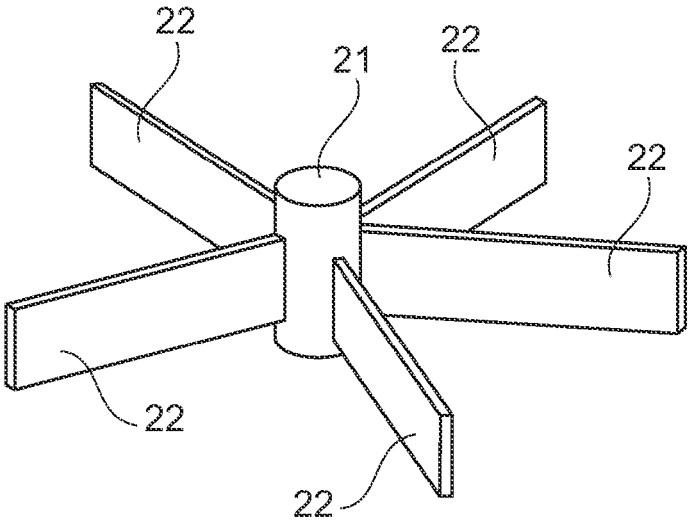

Fig. 3

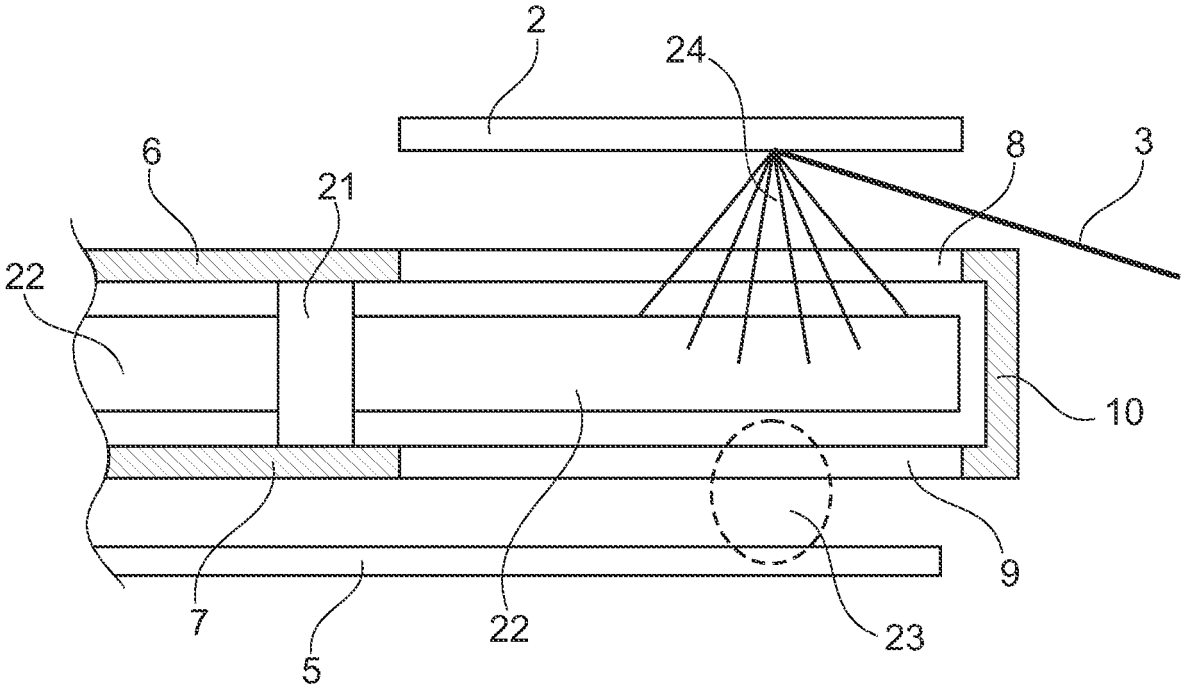

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 10 17 0223

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	23 August 2010	Swiatek, Ryszard

CATEGORY OF CITED DOCUMENTS

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